research paper

ENVIRONMENTAL HAZARDS
Human and Policy Dimensions

Community resilience and vulnerability to disasters: Qualitative models and megacities – a comparison with small towns

BORIS PORFIRIEV*

Risk and Crisis Research Center at the Institute of Economics, Russian Academy of Sciences, Novocheriomushkinskaia, 42a 117418 Moscow, Russia

This paper contrasts the resilience to disasters of megacities with small towns, using vulnerability as a key variable. As an instrument of this comparison a formal model of the communities' vulnerability, further deconstructed into a set of specific modules, is developed and used. It is argued that the megacities' high resilience capacity in the main ensures only a debilitating (although undoubtedly major) effect on them by disaster agents. Meanwhile, the impact on the small towns is often disastrous and sometimes turns into a real catastrophe with some communities totally devastated. However, this observation does not preclude some notable exceptions. To corroborate and highlight the key findings above, empirical data from the Russian experience of the late twentieth to early twenty-first centuries are provided, supplemented by some international illustrations.

Keywords: natural hazards; disasters; vulnerability; resilience; megacities; small towns; models

1. Introduction

It is argued in the disaster literature that metropolitan regions with their large and rapidly growing populations and concentration of wealth, especially those located on the coastline or seismic zones, are most susceptible and worst hit by disasters (see, for instance, Sylves and Waugh, 1990; Institute of Civil Engineers, 1995; Mitchell, 1999; Pelling, 2003). Incidents that would seem to corroborate this include the havoc of 1903, 1948 and 1995 when major earthquake disasters struck San Francisco (USA), Ashkhabad (Turkmenistan) and Kobe (Japan), devastation by the more recent floods in Central Europe in 2002, in Indonesia and UK in 2007, let alone the pictures of London, Madrid, Moscow and New York after terrorist attacks. However, historical and research experience shows that the most obvious and ready-at-hand 'evidence' often proves to be incorrect. A comparative approach to both the actual damage and to the perception of the disaster/hazard by different communities can show important differences.

This paper attempts to compare the resilience to disasters of megacities and small towns using vulnerability as a key variable. To substantiate the investigation and the proposition about differences, it starts with an interpretation of resilience. This involves (a) resistance and adaptive capacity as key conceptual elements important to comprehending the specificity and complexity of resilience as a community's attribute, and (b) vulnerability as its integral metric. The latter provides a conceptual and evaluation tool to understand how and why a hazardous impact on a community such as a big city develops generally only into a major emergency and rarely into a disaster, yet it turns into a major disaster and often into a catastrophe in a small community (i.e. hamlet, town and even small island states like the Solomon Islands, severely hit by a tsunami in April 2007).

■ **E-mail:* b_porfiriev@mail.ru**

doi:10.3763/ehaz.2009.0004 ISSN: 1747-7891 (print), 1878-0059 (online) www.earthscanjournals.com

This is followed by a model illustrating reciprocity between resilience and vulnerability as critical characteristics of a community, which precipitate the escalation of a disaster or the prevention of a catastrophe. The last section integrates the earlier findings of the paper by providing and interpreting a qualitative model of vulnerability of big cities that are contrasted with small settlements.[1]

2. Community resilience to disasters: theoretical issues – vulnerability as an integral metric of resilience

One academic definition implies that resilience has the capacity for collective action in the face of unexpected extreme events that shatter infrastructure and disrupt normal operating conditions. Resilience involves the processes of 'sense making' and creative problem solving in socio-technical systems over time. It incorporates concepts of business continuity, effective governance and self-organization in complex, social systems (Comfort et al., 2009). This definition resonates with that which is recently and widely used by the international disaster practitioner community, which believes resilience is 'the ability of a social system to organize itself and increase its capacity for learning and adaptation to withstand or change in a way to keep the acceptable level in functioning and structure'.[2]

Within the framework of crisis and/or disaster policy both definitions emphasize the capacity of a community as a socio-technical system effectively to prepare, respond to and recover from an impact that would otherwise disrupt its critical functions (both social and technical infrastructure), incur casualties and suffer significant economic damage and/or completely devastate the community as a socio-technical system. The goal of enhancing resilience is to provide a system management capacity and flexibility to keep following its development path (strategy) in conditions of a changing environment. If compared to 'resistance' and 'adaptation', the concept of resilience proves to be the more comprehensive, incorporating the elements of both a community's resistance and adaptation capacity with an emphasis on its self-organizational ability to develop and manage this capacity.

Whatever its merits, resilience is still a concept not yet operational for disaster policy and management or used by grassroots communities.[3] No less important, this and many other definitions of resilience, however apt, are not accepted as universal by social science scholars, who have developed and from time to time keep producing a gamut of their own conceptualizations.[4] Nevertheless, given the above recognition of the comprehensiveness of resilience as a defining characteristic of a community's coping capacity, one should consider its perspective for crisis and disaster management policy.[5] As to its definitions, broader conceptualizations are worth adding which link resilience and vulnerability.

The point here is that whatever the formulation of vulnerability,[6] its key parameters are the impact to which a system is exposed, its exposure (sensitivity) to that impact and its resistance/adaptive capacity. Thus, vulnerability and resilience have common elements, which involve the hazardous impact experienced by a social or socio-technical system, the resistance of the system and the capacity for adaptive action. Clearly, the points of the two concept's convergence could hardly be overestimated when considering directly contrary attributes of the system's coping capacity: while resilience stresses a community's ability to withstand the hazardous impact and maintain development, vulnerability puts to the fore the inability or failure to do that.

This predetermines reciprocity between a community's vulnerability and resilience to disasters. On the one hand, vulnerability is influenced by the build-up or erosion of the elements of resilience, primarily the ability to self-organize and act collectively and creatively to cope with the hazardous impact (Adger et al., 2005; Adger 2006). On the other hand, resilience depends on a set of underlying socio-economic and environmental conditions which provide for increasing or decreasing the community's exposure and sensitivity to impact. However, this reciprocity between the two concepts is not linear: for instance, strengthening a small community's resilience does not lead automatically to reducing its vulnerability to a disaster in the case of an extremely severe impact overcoming all protective barriers and turning into a catastrophe (for evidence of this, see below).

Reciprocity between a community's vulnerability and resilience to disasters provides for important theoretical and practical implications. Among the latter, the use of these concepts for the assessment and measurement of a social or sociotechnical system's coping capacity is worth emphasizing. Timmerman (1981) was the first to link resilience and vulnerability and consider the former as the measure of a system's or subsystem's ability to absorb and recover from a hazardous event impact. Building on this, other scholars have added to the development of the proposition, introducing new insights. Particularly worth mentioning is the work by Pelling (2003), which interpreted resilience as a determinant of vulnerability and stresses the role of planned preparation and insurance in anticipating a potential hazardous impact (Timmerman, 1981; Blaikie et al., 1994; Pelling, 2003). In tune with these conceptualizations is our earlier paper, which assumed vulnerability as an integral metric of resilience (Porfiriev, 1999), thus inverting the above interpretation of this dichotomy by Pelling.

These metrics include a set of both objective (qualitative and statistical) and subjective (social construct) indicators that are actually organic elements of risk (hazard) assessment and risk (hazard) perception and evaluation. The issue of perception and subjective interpretation of vulnerability is particularly important; it is often ignored despite the fact that the concept of risk, which is at the core of vulnerability, has been considered a social construct for many years. The situation is further exacerbated by many lay people believing recurrent adverse occasions and events a part of 'normal life', with rare or new disasters perceived from a perspective of survival and not resilience (Heijmans, 2001).

Given this and the paper's focus on the contrast between the resilience and vulnerability of small towns and those of large metropolitan areas, our further analysis will involve the disaggregating of vulnerability into its basic elements and their qualitative description rather than using detailed risk indicators. This will provide for a better understanding of the tendency of a hazardous impact on big cities developing generally into a major emergency and rarely into a disaster whereas in the small communities it escalates into a major disaster and often into a catastrophe. To add transparency and illuminate the dynamics of this tendency, a generic model of escalation from disaster to catastrophe, with a description of its driving forces and indicators, is introduced below.

3. Community vulnerability and resilience: a development model of escalation from disaster to catastrophe

In terms of crisis management policy, resilience and vulnerability reveal a community's preparedness, protection, exposure and non-adaptation to a hazardous impact. This precipitates the aggravation of a minor crisis into a major crisis, or an emergency turning into something much worse, even into a catastrophe. Figure 1 shows two different paths or models of such development.

One of these paths involves a bifurcation directly from the hazardous impact on a community, with an emergency immediately transforming into a catastrophe with no time and room for disaster. Otherwise, a catastrophe may arise from a disaster, which in turn may either evolve from an acute crisis extending to a protracted crisis, or flare up from a minor crisis or emergency expanding and aggravating to a major fast-burning crisis (Table 1).

The former 'bifurcation' model provides for catastrophe factors associated *either* with the overwhelming devastating effect of a natural or man-made event given that whatever resistance

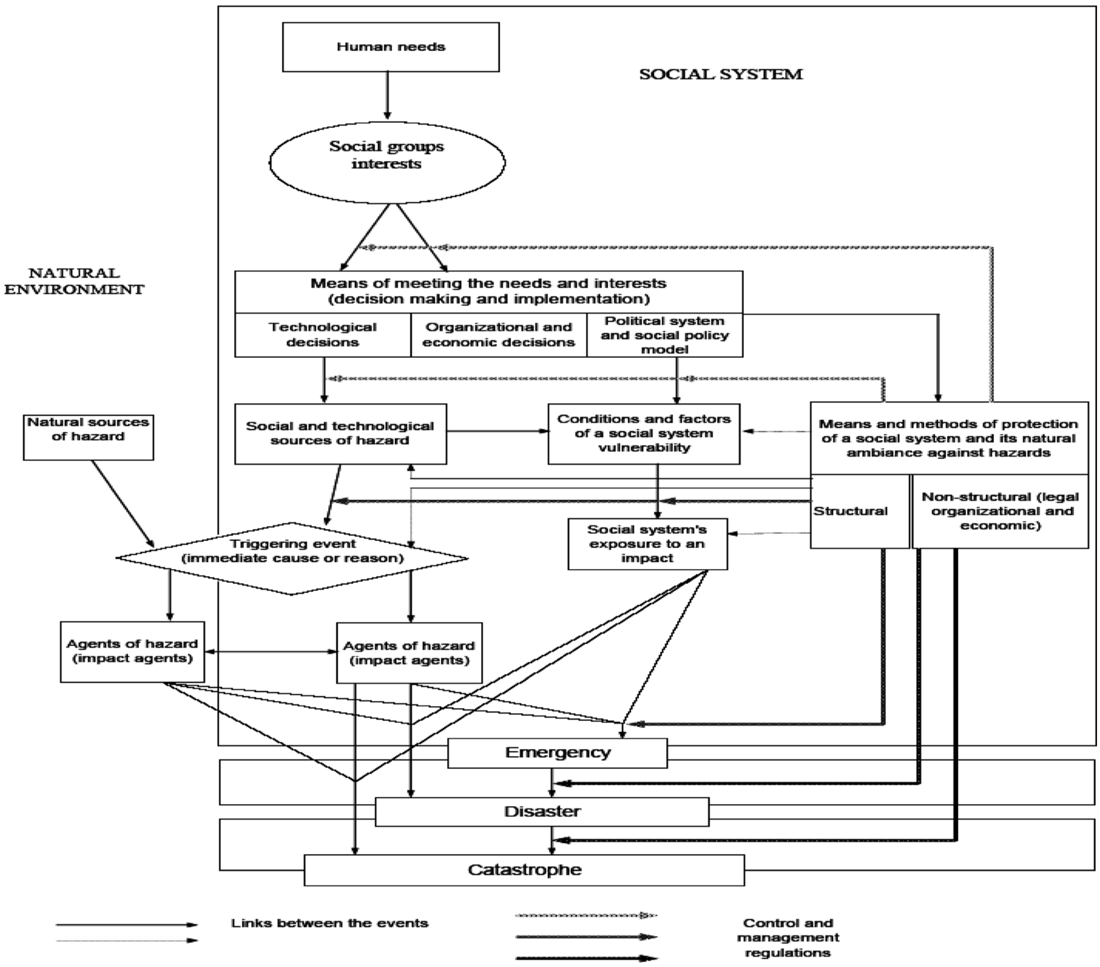

FIGURE 1 Crisis development: factors and path stages. *Source*: Porfiriev, 1998, p. 38 (edited).

or resilience is present a community can in no way cope, *or* with the underlying set of poor socio-economic conditions and/or major failures in a community's preparedness, response to and recovery from disaster, i.e. vulnerability. The latter 'evolutionary' model implies that the disaster impact on a community (not a historical record) unequivocally deals with the community's vulnerability and resilience. This echoes the 'pressure and release' model of hazards proposed by Blaikie et al. (1994), who assumed that hazards represent one pressure and characteristic of vulnerability and that a further pressure comes from the cumulative progression of vulnerability, from root causes through to local geography and social differentiation. These two pressures are cumulative in disasters.

Vulnerability and resilience are associated with the two sets of the community's basic characteristics: first, the development level (often associated with the level of well-being and/or life quality) and type (social and geographical conditions) of an impacted community. An equally severe impact on relatively similar protected communities could produce qualitatively different political, social and economic implications, which would require different disaster policies, in particular in terms of planning. For instance, one could easily imagine the contrast between the actual impact of a unique or series of

TABLE 1 Development of emergency into disaster and catastrophe: interpretation of the stages

Crisis type/stage	Qualitative (verbal) description
Emergency (acute crisis)	Involves temporary break of normal social routines, relatively limited number of affected people (casualties) and economic damage in a given social system, which could be almost fully recovered (compensated) within a comparatively short time.
Disaster (chronic and/or persistent crisis)	Involves long-term and overall break and substantial rupture of the social routines (communications) and structures within a social system including human losses, health and/or environmental deterioration, considerable distress load on the affected community, huge material damage which may be restored, rehabilitated and compensated to a significant degree within a comparatively long-term perspective only.
Catastrophe (devastating overwhelming crisis)	Involves long-term, complete break and rupture of the social communications and structures within a given social system including numerous human losses and casualties, mass health deterioration and morbidity, huge distress load on the affected social community and stress over neighbouring and more distant communities, enormous and practically irreversible social, environmental and material damage that may be partially covered somewhere in a distant future only

Source: Porfiriev, 1998, pp. 58–59 with improvements.

devastating disasters like the Pinatubo volcanic eruption in 1991, the 2004 South-East Asian tsunami or the Katrina, Rita and Wilma hurricanes on a US metropolitan area and that of Singapore leaving alone the other much less developed small island states. In the former, the extreme situation would force the total evacuation of people to the neighbouring regions, which would mean a major national disaster. In the latter, such occasions would be considered a total catastrophe with most of the nation disappearing.

This highlights the difference between resistance and resilience. While one could fairly consider a given US metropolitan area and Singapore comparatively equally resistant to disasters, the example above proves that the same is not true for resilience. This illustration also ignores the difference in public perception of both the disaster risk and the salience and effectiveness of disaster policy. The contrast is no less impressive between the hazard impact on urban areas in developed and developing countries, and between that produced on a small remote town and on a metropolitan area (see below).

Second, one should mention the comprehensiveness, consistency and timeliness of disaster mitigation, coping and alleviation procedures and measures; and leadership, competence and accountability of management and personnel carrying these out as critical components of business continuity and community/national resilience. Failure of one or a few of these crisis management elements may facilitate or trigger an escalation from disaster to catastrophe. The risk of such a failure is never zero, given the heterogeneity of a community to be protected and the complexity and uncertainty of disaster mitigation and alleviation to prevent escalation to catastrophe. However, as social theory and policy/management practices show, the type of political regime, social order and organization pattern (at a corporate level), which creates the framework and environment of a particular crisis decision support and decision-making arrangement, plays a major role in reducing such risk.

Worthy of special consideration is the issue of openness, or in a broader sense the democratic nature of a given organizational or social system. Repeatedly, evidence reveals the applicability and utility of a command-and-control approach towards crisis management by deploying and using an incident command system. This creates the temptation to consider it a universal crisis management tool to be employed everywhere. However, its efficiency in reducing the risk of a disaster's escalation to a catastrophe is constrained by the relatively short 'hot' or 'burning' stages of crisis response and immediate alleviation. Even at this stage, as experience of using the army as rescuers during the 1995 Hanshin-Awaji major earthquake disaster in Kobe (Japan) shows, efficiency could not always be guaranteed. Primarily this is because it precluded or constrained would-be improvisation; this is particularly important in the conditions of uncertainty and complexity that are fertile grounds for the escalation from disaster to a major disaster and eventually to a catastrophe.

Moreover, in times of so-called normalcy (i.e. routine life), when a community or nation should prepare for crises and disasters, relying on a command-and-control model would mean excessive centralization, isolation and insulation of a social and/or organizational system,[7] and a more technocratic and bureaucratic mode of decision making and implementation.

Such types of culture, worldview and operational arrangements are dominated by the superiority of 'political expediency' over human values, of means and methods over the goal, of tactical aims over the strategic mission and of symbolism over reality. Human conscience, morale, empathy, social responsibility and even the value of human life are considered less or least important. A set of relevant examples would bring to light the poor welding of reinforcement bars and loosening of cement by adding too much sand to concrete mixtures in the construction of residential and other buildings in Armenia and Turkey that were then completely destroyed by major earthquakes in 1988 and 1999 respectively. Or one could highlight the case of the 'Kursk' submarine in Russia in 2000 when a pronounced delay in appealing to the international sea rescue community cost the lives of 118 servicemen (Porfiriev, 1998; Mezhenkov, 2000; Gulkan, 2001).

As a result, control, manipulation and covering up information – including in the media – are employed, which distort the real picture of a disaster and create favourable conditions for it escalating into a catastrophe. One could immediately cite the radiation disaster in Chernobyl in 1986 that badly affected unwarned communities including big cities and small hamlets in and outside the former Soviet Union; or the more recent 'Kursk' disaster; or the toxic spill in China in 2005 that was covered up for some weeks, thus allowing the chemicals to contaminate vast areas to the North including those in the Russian Far East (see Porfiriev, 1998; Mezhenkov, 2000; RBC, 2006).

In addition, it should be specially noted that information distortion and shortage, the major obstacle to efficient management that stems from the above-mentioned command-and-control model of disaster policy and institutional rigidity, could be precipitated by the low level of economic development associated with resource scarcity, further aggravated by the geographical remoteness of a specific area (Porfiriev and Svedin, 2002). As our analysis below shows, this is particularly important for the small towns and hamlets in large countries like Russia, expanding over 11 time zones. Eventually, all these factors contribute to the communities' increasing vulnerability and lessening resilience to disasters.

4. A qualitative model of a community's vulnerability to disasters: megacities vs. small towns

The conceptual model above shows resilience and vulnerability as serving a key role in understanding the sequence and dynamics of disaster escalation into a catastrophe. However, it does not reveal the critical thresholds that a social (or socio-technical) system should reach or cross to pass from the state of emergency to disaster or catastrophe. The proposition of critical thresholds implies the introduction into the normative concept of resilience of a specific set of empirical metrics, which the community should perceive as 'red lines' or at least benchmarks.

Following the earlier suggestion which assumed vulnerability as an integral of metrics of resilience, these criteria should involve acceptable risk standards with specific indicators characterizing the elements of the community's vulnerability to disasters. However, given its complexity, vulnerability is not easily quantifiable and could hardly be reduced to a single metric like the decrease of well-being of individuals shown in equation (1) or its derivatives in Table 2 proposed by Adger (2006, Appendix 1).

$$V_a = 1/n[\Sigma(W_0 - \underset{i=1}{W_i}/W_0)^{\alpha}] \qquad (1)$$

where V_a is the vulnerability indicator, W_i the well-being of individual i; W_0 the threshold level of well-being representing danger or vulnerability; n the total number of individuals (whether households, farms, settlements or whatever); q the number of individuals above the vulnerability threshold; α the sensitivity parameter and individuals are ordered from bottom to top (W_1 is more vulnerable than W_2 and so on).

Following a neoclassical economic approach, these models are based on an individual function of well-being, which blurs collective preferences (assumed here are preferences to reduce vulnerability to an acceptable risk level; however, these also could be treated as resilience preferences to maintain this level of risk). This fails to consider the impact on an exposed community, being mentioned earlier as an intrinsic attribute of vulnerability.

These and other complications reveal the serious challenges experienced in the search for an adequate set of resilience and vulnerability metrics, which so far have not been developed and used operationally, and ensure that scholars keep persistently seeking them (see Adger, 2006). Undertaken below is an attempt to join in with this effort and to propose a model which considers vulnerability in a comparative context and contrasting criteria indicators of megacities and small towns. This model should be seen as generic and a preliminary (and clearly disputable) version limited to communities' vulnerability to disasters and designed at this early stage to integrate in a concise way the findings in the earlier sections of this paper.

The set of factors which precipitate and catalyze a hazardous impact on a community, taking the magnitude and severity of disaster and then escalating into a catastrophe and eventually determining vulnerability (or conversely the resilience) of the community in a formal way, could be written as

$$V_c = f[S_i, E_c, (AC)_c^{-1}] \qquad (2)$$

TABLE 2 Vulnerability measures and their interpretation

Measure	Formal interpretation	Verbal interpretation
Proportional vulnerability	$V_0 = q/n$	The proportion of the relevant population (individual components of a system) that are classed as vulnerable. This is a 'headcount' indicator and does not account for the degree of vulnerability of the individual.
Vulnerability gap	$V_1 = 1/n\ [\Sigma_{i=1}^{q}(W_0 - W_i/W_0)^1]$	The aggregate scope of vulnerability measured in well-being terms: the summed distance of well-being for each individual from the vulnerability threshold level of well-being. Action to reduce vulnerability could focus either on reducing the number of individuals that cross the threshold or the scale of their vulnerability.
Vulnerability severity	$V_2 = 1/n\ [\Sigma_{i=1}^{q}(W_0 - W_i/W_0)^2]$	The severity of vulnerability is measured by weighting the distribution of the vulnerability gap within the vulnerable population. The greater the vulnerability is skewed towards the most vulnerable, the greater the severity.

where V_c denotes vulnerability of a community; S_i severity or magnitude of hazard impact, E_c, community's exposure, and $(AC)_c$ community's adaptive capacity.

The right-hand part of equation (2) could be further unpicked in the following way:

$$E_c = f(N_c, C_c) \quad (3)$$

where N_c symbolizes the number or proportion of people and C_c the tangible values (assets) or proportion of these in an exposed community, and:

$$(AC)_c = f(S_c, W_c, E'_c, A_c, F_c, L_c, M) \quad (4)$$

where S_c denotes the structural adjustments (construction quality of residential buildings, industrial and protection facilities, e.g. dams, etc.) in a given community or area; W_c the availability and efficiency of hazard warning; E'_c the emergency services' response capabilities (SAR, medical, transportation services, evacuation planning and early evacuation); A_c the public and infrastructure facilities' personnel awareness and capacity to cooperate; F_c the availability of funds for response and recovery; L_c the availability and efficiency of logistics and management support for response and recovery; and M the availability of the local, regional and national media support (publicity and official recognition of a disaster).

A closer look at the effect of some variables which make up components or elements of the communities' vulnerability to disaster agents and eventually determine their resilience, and contrasting those in the megacities to those in small towns, reveals a complicated and often controversial picture, as shown in Tables 3–10 below. These tables assume a 'typical' megacity and a small town in developing and transitional economies, except in cases with special reservations. As elsewhere, $<$ denotes less than, $\leq$ less than or equal to; $>$ more than and $\geq$ more than or equal to.

The data in Tables 3 and 4 show that a typical big city – in contrast to a small town – is more exposed to industrial accidents (the exception being small and medium towns/factories), less or equally exposed to natural hazards with usually a higher probability of destruction. However, a megacity, when it is exposed to and actually affected by disaster agents, often experiences much less risk of huge economic damage, which if it occurs covers a minor part of the metropolitan area (see Table 4). This stems from their relatively higher adaptive capacity to disasters, which involves not only more widely used structural adjustment measures, more available and better developed warning systems, better logistics and management support systems, much more efficient emergency response services and funds available for response to and recovery from disasters, but also much higher political and media support (Tables 5–10). At the same time, small towns lack the political influence and economic power of megacities that determine resilience capacity no less than the availability of the funds. In addition, in contrast to megacities, in relation to the absolute number of people at risk, a far higher proportion of the living area and population of small towns are often exposed and affected (Cross, 2001; and see Table 4).

Of course, the finding above is too generic to consider it a universal rule. One could easily cite a few examples showing small towns to be more resilient than big cities against specific hazards and in a specific social domain. For instance, a small or medium town in a developed nation with the notable exception of the capital city or

TABLE 3 Comparative severity of disaster impact

Vulnerability component	Criteria	Indicator	Megacity	Small town
S_i	Probability of destruction	Frequency/sq km	More often	Less often
	Degree of destruction	Percentage of the total affected area	Small/medium	Large/enormous

TABLE 4 Comparative exposure to disaster impact

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small town
E_c	Floods	Probability of event (P_e) and proportion of a people (N_c) and facilities (C_c) experiencing it (%)	$<$	
	Earthquakes		$\le$	
	Hurricanes		$\le$	
	Industrial accident		$>$	

TABLE 5 Comparative structural adjustments to disasters and publicity of a disaster event

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small town
E_c	All types of hazards	Number and equipment of SAR personnel, firemen, hospitals and medical personnel (both absolute and per number of residents)	$>$	
M_c		Visibility and publicity of a disaster event	$>$	

TABLE 6 Comparative emergency response capacity

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small town
S_c	Floods	The number and height of flood levees, dams, proportion of reinforced and retrofitted structures and redundant safety systems	$>$	
	Earthquakes		$>$	
	Hurricanes		$>$	
	Industrial accident		$>$	

TABLE 7 Comparative availability and efficiency of early warning of disasters

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small town
W_c	Floods	Number of river gauge stations, radio and automatic warning systems and their functionality	$>$	
	Earthquakes		$>$	
	Hurricanes		$>$	
	Industrial accident		$>$	

at the centre of hazardous industries is less vulnerable to international terrorist attack than a big city, which seems a more attractive target to terrorists. However, the same is not true for developing or transitional societies in a state of war or armed conflict, as the cases of Afghanistan, Iraq, Russia (North Caucasus region) and Sudan demonstrate.

TABLE 8 Public and infrastructure facilities' personnel awareness and capacity to cooperate

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small town
A_c	All types of hazards	Awareness	>	
		Capacity (willingness and readiness) to cooperate	<	

TABLE 9 Comparative availability of funds for disaster response and recovery

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small town
F_c	All types of hazards	Amount of response and recovery allocations:		
		– in absolute terms (US$)	>	
		– per household affected	≥	

TABLE 10 Comparative availability of logistics and management support for response and recovery

Vulnerability component	Type of disaster agent	Indicator	Megacity	Small town
L_c	All types of hazards	Amount response and recovery L&M support:		
		– in absolute terms (US$)	>	
		– per household affected	≥	

In addition, certain elements of the small towns' adaptive capacity are more developed and can cope better with disasters than those of the big cities. Particularly worth mentioning here are the informal channels of information, which make up an important part of W_c and A_c components of communities' vulnerability (and resilience) to disasters. Or the readiness and willingness to cooperate during response to and/or recovery from disasters, thus revealing the social capital accumulated in a given community, which are critical to the A_c component. The 'superiority' of these elements of the small towns' adaptive capacity is an important characteristic in both developed and developing economies, and also in transitional economies.

These reservations provide important findings about the non-linearity of the tendency of the major cities to be more resilient to disaster impacts than small towns. In future in-depth research will be needed to test these matters, but already disaster practitioners should bear in mind the salience of the above-mentioned conditions as factors precipitating specificity of disaster planning in different types of communities.

In general, the above tendency should be perceived as being correct in all social and geographic conditions, and as such one might find it consistent with the realities of Russia. A handful of Russian megacities, with slightly more than a quarter of the total population, concentrate economic power in terms of capital assets and even more in financial resources (see Table 11).

Leaving aside human capital, which is embodied in modern construction and organizational technologies and in those who develop and use them to provide more efficient disaster risk reduction and which is also highly concentrated in metropolitan cities, this implies more funding for strengthening megacity communities' resilience. In turn this implies less vulnerability and much less risk

TABLE 11 Population distribution and financial flows in Russia

	% total population[1]	% total capital assets[2]	% total financial flows[2]
Rural	27	15	5
Urban	73	85	95
(Megacities[3])	(18)	(48)	(85)
Total	100	100	100

[1] Rounded numbers from official statistical sources.
[2] Author's assessment.
[3] 12 cities with more than 1 million people each including Moscow (11 million) and St Petersburg (5 million).

of escalation from disaster to catastrophe. To the contrary, the small towns and hamlets, particularly those in the Urals and remote areas of Siberia and the Far East, lag considerably behind their 'big brothers' in every or almost every respect considered above. The notable exceptions are a limited number of relatively more resilient small communities, mostly those of research centres in close proximity or, on the other hand, those distant from metropolitan areas, but these examples do not change the general picture.

It is sufficient to cite one example, that of the fire services. Fire safety in metropolitan areas in Russia with a total population of some 16 million people, primarily living in Moscow and St Petersburg regions and seven more big cities with more than a million inhabitants, is maintained completely or almost completely by municipal and industrial fire brigades using mostly adequate equipment, although some of it is obsolete and not effective. However, this should be contrasted to the 37 million people living in small towns and industrial hamlets, who lack any fire service at all. Moreover, seven million of these people lack any line of communication including telephones, which means that they have no chance of seeking help from outside their immediate community. The implications of these conditions could be and actually are disastrous.[8] To corroborate this important point a set of tables in the Appendix to this paper provides comparative data that contrast the impact and implications of specific disasters in the Moscow metropolitan area and the smaller communities in Russia.

Another important piece of evidence of the latter being more prone to disasters deals with the M_c component of vulnerability, i.e. with visibility and publicity of a disaster event, and especially the political and economic salience of the impacted community. It discloses the cases of the small towns, hamlets and villages where safety is 'exchanged' for – or even sacrificed for – the sake of the big cities. This practice may be a part of, first, the national security and/or civil defense policy of locating some critical facilities such as nuclear power or industrial units (including military bases) in Russia, the UK or USA outside the big cities so as to reduce the risk of damage (say by vandalism) and/or to ensure the secrecy and concealment of these facilities. This policy indirectly increases vulnerability of the small towns to incidents such as terrorist bombing compared to big cities. Second, it may stem from a specific disaster policy, in particular that of flood management during crises. From time to time in many parts of the world the practice of opening dams or locks to allow massive floodwater streams to miss the major cities and flood smaller communities down-river has been used as a planned operation. These small towns, hamlets and villages receive an early warning, the people are evacuated before the waters swamp the streets and houses, and households receive compensation.[9] However, sometimes in Russia this practice has not worked satisfactorily. During the major floods in the Krasnodar region in summer 2002 some settlements were washed away with over a hundred inhabitants killed (see Appendix 1B). Five years later, in July 2007, opening the spillways of the dam at the huge hydropower station on the Zeya River in the Far East caused inundation of the adjacent communities, which in turn caused the destruction of 63 houses and the evacuation of over 400 people from the small town of Zeya and Ovsianka village, and caused economic damage of almost US$ 2 million.[10]

5. Conclusions

The analysis above leads to two major conclusions. One of these implies the validity of the resilience concept as a useful analytical and policy tool of disaster risk management, in particular for a comparative assessment of small towns and metropolitan areas' exposure to, preparedness for, response to and recovery from disasters. Its salience should not be underestimated, with the analytical potential of the concept further strengthened by considering vulnerability and its key components' integral metrics of resilience. The proposed qualitative model of vulnerability provides a set of criteria and specific indicators to measure particular components of adaptive capacity as a key element of both vulnerability and resilience in a comparative perspective (megacities vs. small towns). It should help to enhance the merits of the concepts of resilience and vulnerability as its metrics suggest. However, the model itself needs empirical verification using statistical data from different geographical and social areas, creating a future research agenda.

Secondly, the comparative analysis of megacities and small communities' vulnerability and risk of escalation from a disaster to catastrophe, although undoubtedly far from exhaustive, reveals a much more complicated picture than typically portrayed. One of these complications involves a non-linear reciprocity between vulnerability and resilience: an increase of the former does not automatically imply the same for the latter and vice versa. No firm evidence exists that metropolitan areas are more vulnerable to disaster impacts. The other complication reveals a tendency of the megacities to be comparatively more resilient than small towns, which, however, is true only where the environmental and social conditions of both communities are equal or similar.

This provides a lesson and calls for a more balanced approach to both practical policy and research in the area of disaster risk management and crisis policy. From an academic perspective it pinpoints more focus on regional studies and comparative explorations of communities' vulnerability and resilience. In policy terms this implies more attention of the federal and regional authorities and media to the small towns and villages in hazard-prone areas. This in turn implies an elaboration and implementation of a framework that would marry disaster risk reduction and development programmes, and enable local population participation, which is critical to address the root causes of vulnerability and the basics of resilience policy. More specifically, it means political, financial and organizational assistance to build resistant communities at the pre-crisis stage, efficiently rescue affected people and reduce the damage at trans-crisis stage, and to recover from disaster after the crisis impact subsides. Meanwhile, the megacities should rely more on intercity, intra- and interregional cooperation to share more equally the federal resources involved in disaster management, especially for mitigation. These measures, if put together, will provide for a significant contribution to reduce the risk of disasters and prevent their escalation to catastrophic proportions.

Appendix 1.

Appendix 1A. Hurricane in Moscow, 1998

TABLE 1A.1 A snapshot of Moscow city

Area	900 km^2
Population	8.5 million
Population density	9,444 people/km^2
Share in GDP	~20%

TABLE 1A.2 Hurricane profile

Timing	22:00, 20 June 1998
Wind speed	20–30 m/sec
Rainfall	150 mm/day
Hail	5–15 mm hailstones

TABLE 1A.3 Impact and damage

Number of people affected:	6.5 million
Killed	9
Injured	173
Hospitalized	122
Number of houses damaged (roofs and windows)	~100
Direct economic losses	~3.5 US$ million

TABLE 1A.4 Recovery data (days)

Rehabilitation of electricity lines and roads	0.12–0.15
Repair of damaged houses	3–4
Clearing away fallen trees	150–180

Appendix 1B. Earthquake disaster in Sakhalin, 1995

TABLE 1B.1 A snapshot of Sakhalin Island

Territory	76,000 km^2
Population	700,000
Population density	9.2 people/km^2
Population of Neftegorsk	3,000

TABLE 1B.2 Quake profile

Time of occurrence	1:04 a.m. (local time)	28 May 1995
	1:04 p.m. (GMT)	27 May 1995
Magnitude	7.1–7.6 (Richter scale)	

TABLE 1B.3 Impact and damage in Neftegorsk

Number of casualties		Damaged facilities	
Instantly killed	1,989	Buildings[1]	26
Missing	350	Houses totally destroyed	17
Injured	375	Houses severely damaged	0
		Houses partially destroyed	9
		Other buildings	9

[1] Municipal houses only. More than 1,500 private houses are not included.

TABLE 1B.4 Impact and damage to lifeline utilities[1]

Suspension of water supply	All houses in Neftegorsk for 24 hours
Impact on electrical grid lines	200 km
Impact on communications (telephone)	300 km
Impact on oil pipelines	45 km
Impact on gas pipelines	1 km
Suspension of oil and gas terminals	3
Direct economic losses	100 US$ million
Indirect economic losses	300 US$ million

[1] Porfiriev, 1998, p. 176.

TABLE 1B.5 Comparative vulnerability to Kobe and Neftegorsk earthquake disasters

Indicator	Neftegorsk[1]	Kobe[1]
Number of people killed	~2000	~6500
As percentage of the total population	72	0.4
Direct economic losses	100 US$ million	114,000 US$ million
Recovery potential	Zero	Full

[1] Rounded numbers.

Appendix 1C. Catastrophic floods in Yakutia, May–June 1998

TABLE 1C.1 A snapshot of Yakutia

Territory	3,103,000 km^2
Population	1.07 million
Population density	0.4 people/km^2
Temperature:	
January	–28°C/–50°C
July	+2°C/+19°C

TABLE 1C.2 Impact and damage

Districts affected (total)	20
Districts affected (% of total)	58
Communities affected	171
Number of people affected:	~500,000
Killed	19
Evacuated	51,000
Homeless	47,773
Buildings and facilities damaged:	
Residential (houses)	15,245
Industrial units	914
Social infrastructure units	456
Boiler-houses	130
Bridges	312
Dams	213
Worst affected small town (Lensk)[1]	
Population	38,000
Area of town inundated	72%
Houses partially damaged	92%

[1] In Spring 2001 catastrophic floods of the same severity completely destroyed Lensk.

Appendix 1D. Catastrophic floods in the south of Russia, 2002

TABLE 1D.1 Impact and damage

Territory affected	Nine regions – total population of ~11 million people
Number of communities affected	303
Number of people affected:	>500,000
Killed	114
Evacuated	106,000
Homeless	>400,000
Houses damaged	40,463
Houses totally destroyed	7,703
Direct economic losses	470 US$ million
Recovery potential estimate (months)	
Rehabilitation of the main lifelines (water, electricity, gas) and roads[1]	1.0–1.5
Rehabilitation of houses[2]	12–18
Full rehabilitation of property including, belongings, livestock[3]	48–60

[1] Estimate based on official EMERCOM data on the pace of recovery works.
[2] The order of the President of Russia.
[3] Estimate based on the ratio between actual compensation allowances and value of property loss.

Notes

1. This section of the paper builds and expands upon propositions and empirical evidence provided in solid contributions by Handmer (1995), Parker (1995) and Cross (2001). Added to these are some recent data including that on Russia, which have rarely if ever been cited in crisis and disaster research literature.
2. See UN/ISDR, 2002. In this paper definitions of resilience other than social science definitions, for instance those of ecology and environmental science, are deliberately not considered. However, one can easily locate them in a very useful overview by Longstaff (2005).
3. Given this, Klein et al. (2003) cast doubt on the resilience concept's usefulness as such.
4. Some of these that tackle communities' resilience to natural hazards are overviewed by Klein et al., 2003.
5. Some scholars believe a concept of robustness has no less merit than resilience. From my perspective, robustness corresponds more with technical and/or socio-technical systems at microeconomic level (organization, facility, etc.) rather than big complex systems like human settlements. The key attribute organic to such complex systems is self-organization, which provides for their contemplation considering binary processes 'resilience–manageability' and 'resilience–development', missing in interpretations of robustness.
6. An overview of these formulations is provided in Adger, 2006.
7. On isolation and insulation effects of disasters on the economy, see Albala-Bertrand, 2006.
8. EMERCOM Minister's TV comment on the implications of the major fire that killed 62 people in a retirement house at Kamishevatskaia village by the Azov Sea, Krasnodar region.
9. As far as we know, such a practice was employed by regional authorities in the UK during disastrous floods in late June 2007.

10. *Zeyskaya GES obviniayetsia v uscherbe na 40 millionov rublei* (Zeyskaya Hydropower Station is convicted in causing damage worth 40 million rubles). www.vz.ru/news/2007/7/26/96814.html; Leskov, 2007.

References

Adger, W. N., 2006. Vulnerability. *Global Environmental Change*, 16. 268–281.

Adger, W. N., Hughes, T. P., Folke, C., Carpenter, S. R. and Rockstrom, J., 2005. Social-ecological resilience to coastal disasters. *Science*, 309. 1036–1039.

Albala-Bertrand, J.-M., 2006. *The Unlikeness of Economic Catastrophe Localization and Globalization*. Presentation at the SEMA Conference on Future Challenges of Crisis Management in Europe, Stockholm, 3–5 May 2006.

Blaikie, P., Cannon, T., Davis, I. and Wisner, B., 1994. *At Risk: Natural Hazards, People's Vulnerability and Disasters*. Routledge, London.

Bobneva, M. (ed.), 1992. *The Footprint of Chernobyl: Socio-psychological Processes in the Post-disaster Community (Chernobylskii Sled: Sotsialno-psikhologichesiye protsessi v post-karastrofnom obschestve)*. Votum-Ψ, Moscow.

Comfort, L., Demchak, C. and Boin, A. (eds), 2009. *Designing Resilience for Extreme Events: Socio-technical Approaches*. University of Pittsburgh Press, Pittsburgh, PA.

Cross, J., 2001. Megacities and small towns: different perspectives on hazard vulnerability. *Environmental Hazards*, 3(2). 63–80.

Gulkan, P., 2001. *Rebuilding the Sea of Marmara Region: Recent Structural Revisions in Turkey to Mitigate Disasters*. Issue Paper for a Wharton–World Bank Conference on Challenges in Managing Catastrophic Risks: Lessons for the US and Emerging Economies. Washington, DC.

Handmer, J., 1995. Managing vulnerability in Sydney. *GeoJournal*, 37(3). 355–368.

Heijmans, A., 2001. 'Vulnerability': a matter of perception. *Disaster Management Working Paper No 4*. Benfield Greig Hazard Research Centre, London.

Institute of Civil Engineers, 1995. *Megacities: Reducing Vulnerability to Natural Disasters*. Thomas Telford, Trowbridge, UK.

Klein, R., Nichols, K. and Thomalla, F., 2003. Resilience to natural hazards: how useful is this concept? *Environmental Hazards*, 5(1–2). 35–45.

Leskov, S., 2007. Chem vstretim stikhiyu? (What do we meet a disaster with?) *Izvestia*, 16 August 2007.

Longstaff, P., 2005. *Security, Resilience and Communication in Unpredictable Environments Such as Terrorism, Natural Disasters and Complex Technology*. Harvard University Program on Information Resources Policy Research Report, November 2005.

Mezhenkov, V., 2000. *Atomnaia Podlodka 'Kursk': Khronika Gibeli (Nuclear Sub 'Kursk': Chronicle of the Wreckage)*. Pushkinskaia Square Publishers, Moscow.

Mitchell, J. K., 1999. *Crucibles of Hazard: Mega-cities and Disasters in Transition*. United Nations University Press, Tokyo.

Parker, B., 1995. Hazard transformation and hazard management issues in the London megacity. *GeoJournal*, 37(3). 313–328.

Pelling, M., 2003. *The Vulnerability of Cities: Natural Disaster and Social Resilience*. Earthscan, London.

Porfiriev, B., 1998. *Disaster Policy and Emergency Management in Russia*. Nova Science Publishers, New York.

Porfiriev, B., 1999. Uyazvimost' territorii k vozdeistviyu opasnikh pripodnikh I techno-sotsialnikh processov i yavlenii: voz-mozhnaia metodika otsenki (An area's vulnerability to the impact of hazardous natural, technological and social events and processes: an assessment methodology). *Bezoposnost pri Chrezvichainikh Situatsiyakh (Safety Issues in Emergencies)*, 1. 47–49.

Porfiriev, B., 2005. Managing crises in the EU: some reflections of a non-EU scholar. *Contingencies and Crisis Management*, 13(4). 145–152.

Porfiriev, B. and Svedin, L. (eds), 2002. *Crisis Management in Russia: Overcoming Institutional Rigidity and Resource Constraints*, CRISMART Series Vol. 17. Elanders Gotab, Stockholm.

RBC (Ros Business Consulting), 2006. *China Will Spend US$ 3.28 Billion to Clean Up Sungari River*. http://top.rbc.ru/index.shtml?/news/policy/2006/01/08/08100439_bod.shtml.

Sylves, R. and Waugh, Jr., W., 1990. *Cities and Disaster*. Charles C. Thomas, Springfield, IL.

Timmerman, P., 1981. *Vulnerability, Resilience and the Collapse of Society: A Review of Models and Possible Climatic Applications*. University of Toronto, Toronto.

UN/ISDR (United Nations International Strategy for Disaster Reduction), 2002. *Living with Risk: A Global Review of Disaster Reduction Initiatives*. UN/ISDR, Geneva.